WAC 246-247, RADIATION PROTECTION - AIR EMISSIONS
NOTIFICATION OF MODIFICATION FOR THE 1706-KE LABORATORY
(C-018H PILOT PLANT)

INTRODUCTION

On September 26, 1991, in a letter, A. W. Conklin, State of Washington, Department of Health (DOH), to E. A. Bracken, Department of Energy, Field Office Richland (RL), guidance was provided regarding information required in a notification of modification, pursuant to WAC 246-247-070, for an "insignificant source". (An insignificant source is defined in the letter as, "one that could result in a committed effective dose equivalent [CEDE] of less than 0.1 mrem dose to the maximally exposed individual [MEI] without controls.") This document serves as a notification, pursuant to the September 26, 1991, guidance, for modification of the 1706-KE building to accommodate pilot plant operations for the C-018H Waste Water Treatment Facility. These operations will provide a CEDE of approximately 0.005 mrem/yr to the MEI (see Section 7.0).

Waste waters have been generated as a result of operations conducted at the Hanford Site for over 40 years. These waste waters typically contain trace levels of radionuclides and stable chemicals. Both organic and inorganic constituents can also be present as either suspended solids or dissolved solids. While there is a wide variety of contamination in the waste waters, the level of contamination is very low. (Characterization of the constituents in Hanford Site waste water streams is provided in the stream specific reports [WHC 1990]).

The sources, and a general description of the Hanford Site waste waters having the potential for being tested in the C-018H Pilot Plant, include the following:

- Non-contact cooling waters - Water from the Columbia River is pumped to the Hanford Site and used as non-contact cooling water. "Non-contact" means that the water routinely does not come in contact with dangerous or mixed waste. After the water passes through the unit, the water is monitored and released as a waste water. This waste water could contain trace levels of radioactivity from residual contamination in the piping system.

- Non-contact steam condensates - Water from the Columbia River is pumped to the Hanford Site, demineralized, and converted to steam. This steam is used for building and process heating within the buildings. After passing through the heat exchangers, the condensed steam is monitored and released as a waste water. This waste water could contain trace levels of radioactive contamination from the piping system.

- Process condensates - Hanford Site operations typically concentrate waste in an evaporator before storage in the DSTs. The process condensate is generated by the condensed overhead vapors from the evaporation of the waste. This category of waste

includes the 242-A Evaporator process condensate, which is the only waste water currently determined to be a dangerous waste.

- Laundry waste waters - The operation of the Hanford Site requires the use of protective clothing. This protective clothing is washed in an onsite laundry. Waste water resulting from this laundry process typically has high levels of suspended solids and inorganic contaminants. The waste water also contains trace levels of organic and radioactive contamination.

- Laboratory and chemical sewers - Most waste water discharges to the laboratory and chemical sewers have been eliminated. The majority of the remaining waste water typically results from heating and ventilation systems and from systems used to ventilate various process vessels. This waste water typically contains trace levels of radioactive contamination from the building piping systems.

- Groundwater - The remediation of the Hanford Site is anticipated to include projects designed to remove contamination from the groundwater beneath the site and to remove contamination from the soils above the groundwater. These remediation efforts could require waste water pilot plant testing.

The waste waters described above have previously been discharged to unregulated cribs, ponds, or ditches. However, in May of 1989, the U.S. Department of Energy signed the "Hanford Federal Facility Agreement and Consent Order", agreeing to regulation and treatment of these discharges. Therefore, systems are being designed and will be built to treat these waste waters along with any future waste waters resulting from remediation activities on the Hanford Site.

One of the first treatment systems to be constructed will be the 200 Area Waste Water Treatment Facility (Project C-018H). This facility will be designed to treat the process condensate from the 242-A Evaporator and the Plutonium-Uranium Extraction (PUREX) Plant. However, before the treatment system is constructed, the design of the system must be tested to verify that the proposed treatment methods will be effective. This testing will be performed on a small-scale and is termed 'pilot testing'. Specifically, pilot testing will:

- Demonstrate the technical adequacy, economic feasibility, and performance capability of new and innovative treatment technologies

- Tailor existing treatment technologies to site-specific design needs and operating conditions

- Improve the efficiency of treatment processes and refine performance capabilities

- o Demonstrate methods to reduce secondary waste resulting from treatment processes
- o Demonstrate that treatment systems produce a treated waste water that is nonhazardous
- o Provide data to support the preparation of the required environmental permits, delisting petitions, or other regulator approvals
- o Provide RL with a level of confidence that the treatment system will operate within the limits established by the environmental permits
- o Provide data for full-scale plant design.

A portion of the 1706-KE Building (an existing structure in the 100KE Area) has been selected as the site for most of the testing of these treatment systems. (It is possible that this laboratory will also be used to test treatment systems for other proposed facilities. However, the influent to the C-018H Treatment Facility will provide the bounding source term for any other potential tests.) Figure I-1 depicts the C-018H Pilot Plant floor plan. However, before pilot plant testing can commence, certain minor modifications to the facility HVAC system are necessary. Because pilot plant testing of actual waste will produce emissions to atmosphere of small quantities of radionuclides, approval from the DOH, pursuant to WAC 246-247, "Radiation Protection - Air Emissions", is required prior to commencement of the modifications.

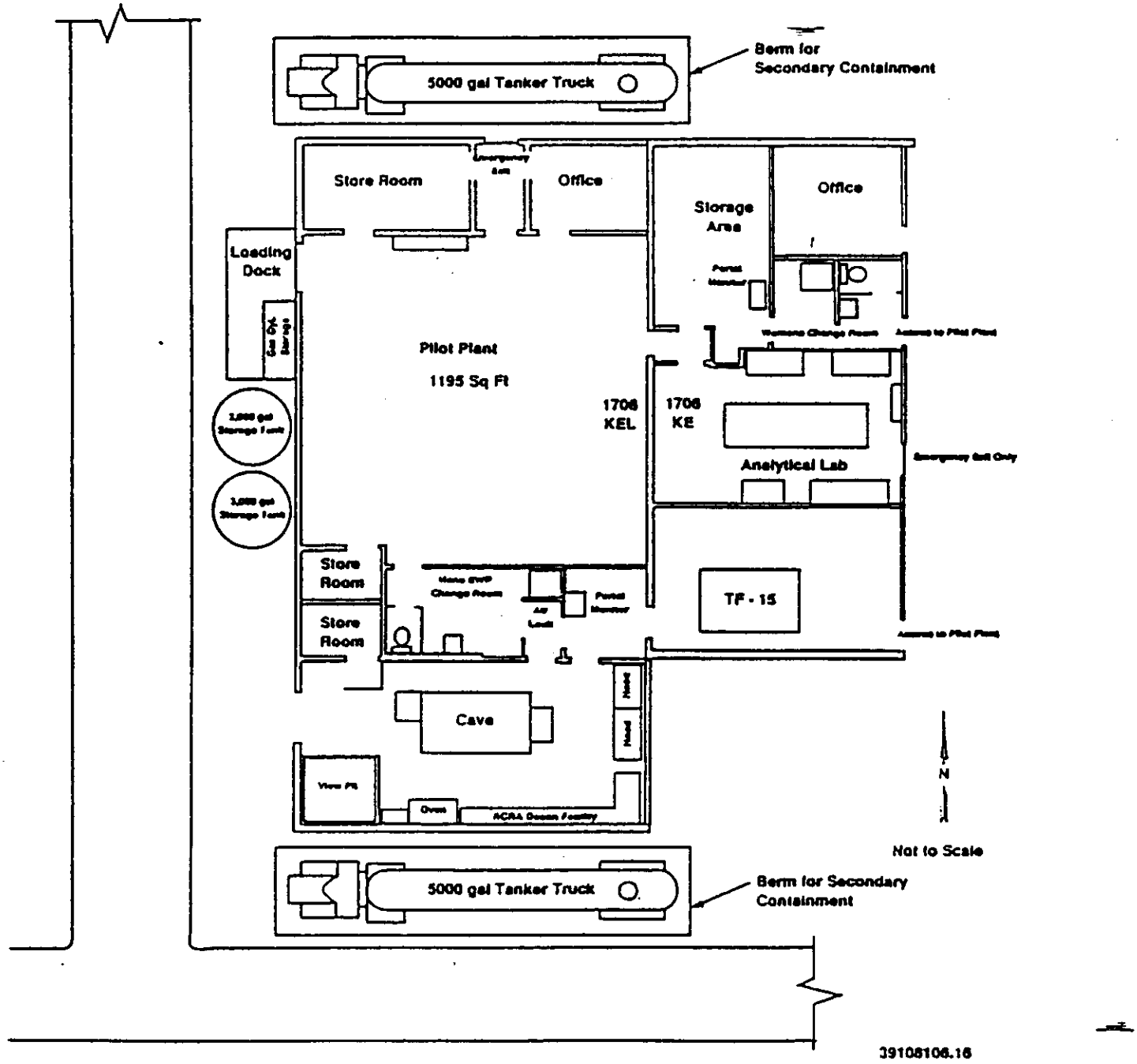


Figure I-1: C-018H Pilot Plant Floor Plan

1.0 DESCRIBE THE CHEMICAL AND PHYSICAL PROCESSES RELATED TO THE EMISSION UNIT

The following discussion has been organized under treatment technologies. Currently, the technologies to be tested in the C-018H Pilot Plant include the following:

- o pH adjustment
- o Organic removal (e.g., ultraviolet light mediated oxidation and granular activated carbon)
- o Inorganic removal (e.g., reverse osmosis and ion exchange)
- o Secondary waste concentration (e.g., evaporation)
- o Suspended solids removal (e.g., filtration).

Figure 1-1 is an overall process flow diagram for the pilot plant.

1.1 pH Adjustment

A pH adjustment step is required in many waste water treatment systems. This step is usually required to change the waste water chemistry, to enhance the removal or recovery of desired contaminants by downstream process equipment, or to adjust the waste water pH to meet regulatory discharge limits.

Adjusting the process stream pH requires an automatic system for adding either an acidic or basic reagent in the precise amount required to change the solution pH so the pH falls within a desired range. This is accomplished either in batches in large feed makeup tanks or inline using two or more relatively small tanks that are well agitated. For example, the pH of the waste water from the Liquid Effluent Retention Facility (LERF) will be above 10 and must be lowered to approximately 4 to 7 before the ultraviolet oxidation step. (The LERF will store process condensate from the 242-A Evaporator and PUREX.) A continuous inline system will be used for adjusting the pH of the waste water stream. The pH adjustment flow diagram is shown in Figure 1-2.

The pH adjustment system will consist of either two or three 50-gallon (189.3-liter) stainless steel tanks, in series. Each tank will be covered, vented to the building ventilation system, have a pH probe, and a mixer to thoroughly mix the acid. The first and second tanks for a two-stage control tank will have control instruments that will automatically adjust the feed rate from an acid or base metering pump. The third tank and pH analyzer will provide an "average" pH measurement, because under some circumstances, the indicated pH in the control tanks could be fluctuating considerably. The pH of the waste water can be raised by using a base such as caustic (sodium hydroxide) and lowered by using an acid (sulfuric acid).

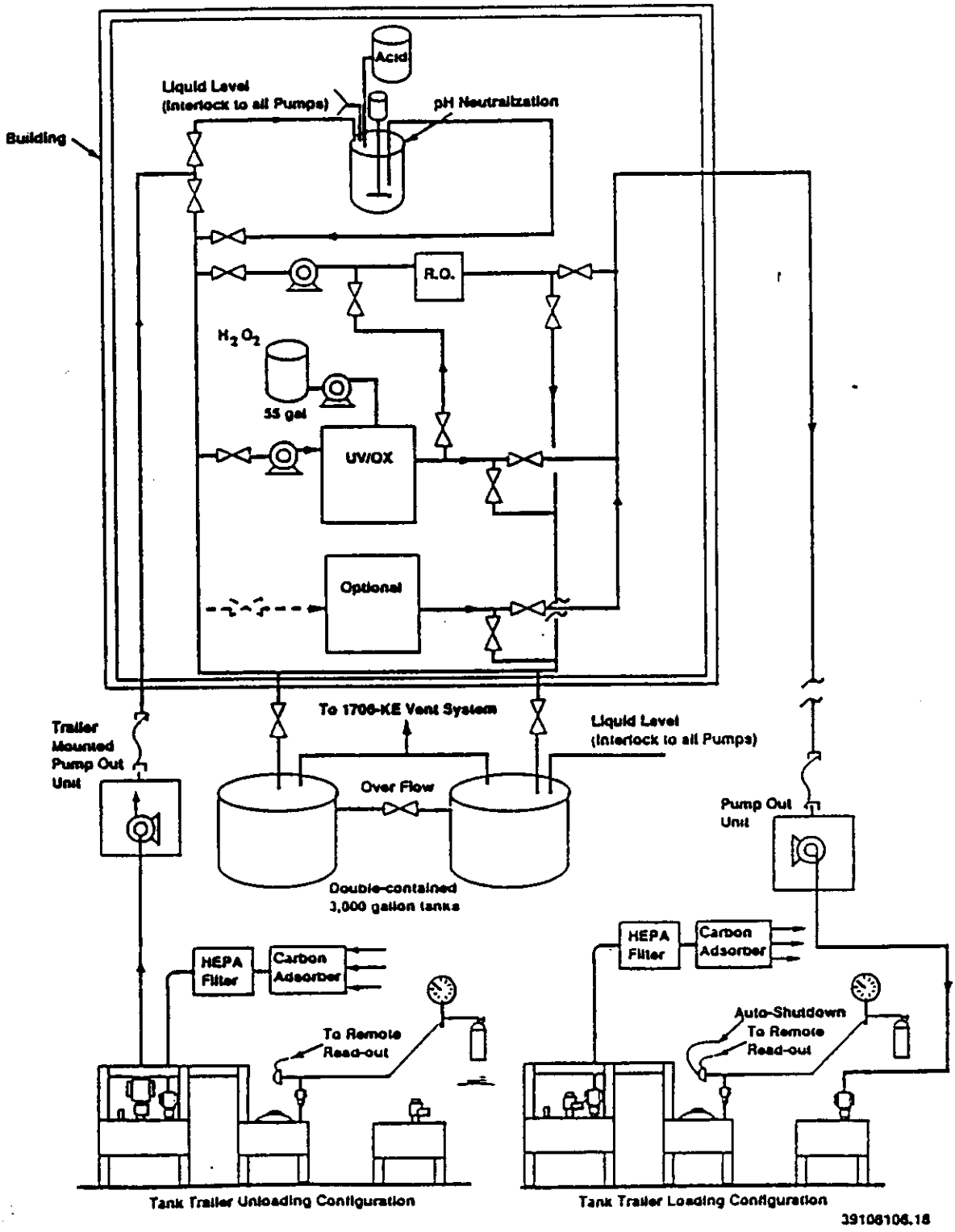


Figure 1-1: Overall Process Flow Diagram

The acid or base will be metered from a separate tank using a metering pump. The pump and tank will be designed to be compatible with the chemical. The concentration of sulfuric acid to be used for pH adjustment could range from 20 percent to 98 percent. The sodium hydroxide concentration could range from 5 percent to 50 percent. If lower concentrations of the acid or base are used, a larger metered volume of acid or base is required, simplifying the pH control. Usually the more dilute the waste water stream, the less acid or base is required for pH adjustment. A typical flow rate of acid or base could range from 0.68 to 3.4 ounces (20 to 100 milliliters) per minute for the 5 gallons (18.9 liter) per minute waste water pilot plant.

1.2 Organic Removal

Organic compounds can be destroyed by using ultraviolet oxidation to convert organics to carbon dioxide and water. When an oxidant, such as hydrogen peroxide or ozone, is acted upon by ultraviolet light, a hydroxyl radical is formed that is a very reactive oxidant. This hydroxyl radical is used to oxidize the organics. The degree of organic oxidation depends on the residence time of the waste water in the ultraviolet reactor, the concentration of oxidant, and the intensity of the ultraviolet light source. The ultraviolet oxidation piping and instrumentation diagram is presented in Figure 1-3.

The oxidation unit has a reactor volume of approximately 30 gallons (114 liters) and is equipped with six ultraviolet lamps rated for 5 kilowatts each. The lamps are mercury vapor lamps, and are considered high intensity. A quartz sheath protects the lamps from the waste water solution. The six lamps have individual switches so any number of lamps can be activated at any one time. The reactor outlet acts as the vessel vent when filling the equipment. Any gas generation during operation will be swept out the outlet piping of the unit to a vented storage tank. The equipment can be operated in a once-through mode or in a recycle mode.

1.3 Inorganic Removal

Reverse osmosis and ion exchange are the two types of inorganic removal discussed in the following sections. Both processes will remove radionuclides from the waste stream. Granular activated carbon requires similar equipment to ion exchange and is, therefore, discussed with ion exchange.

1.3.1 Inorganic Removal-Reverse Osmosis

A flow schematic and piping and instrumentation diagram of the reverse osmosis system is presented in Figure 1-4.

Reverse osmosis is a technology that employs pressure to effect a separation of a solute (contaminants) and a solvent (water). The pressure applied must be great enough to overcome the natural osmotic pressure of the solution. The solution is passed over the surface of a semi-permeable

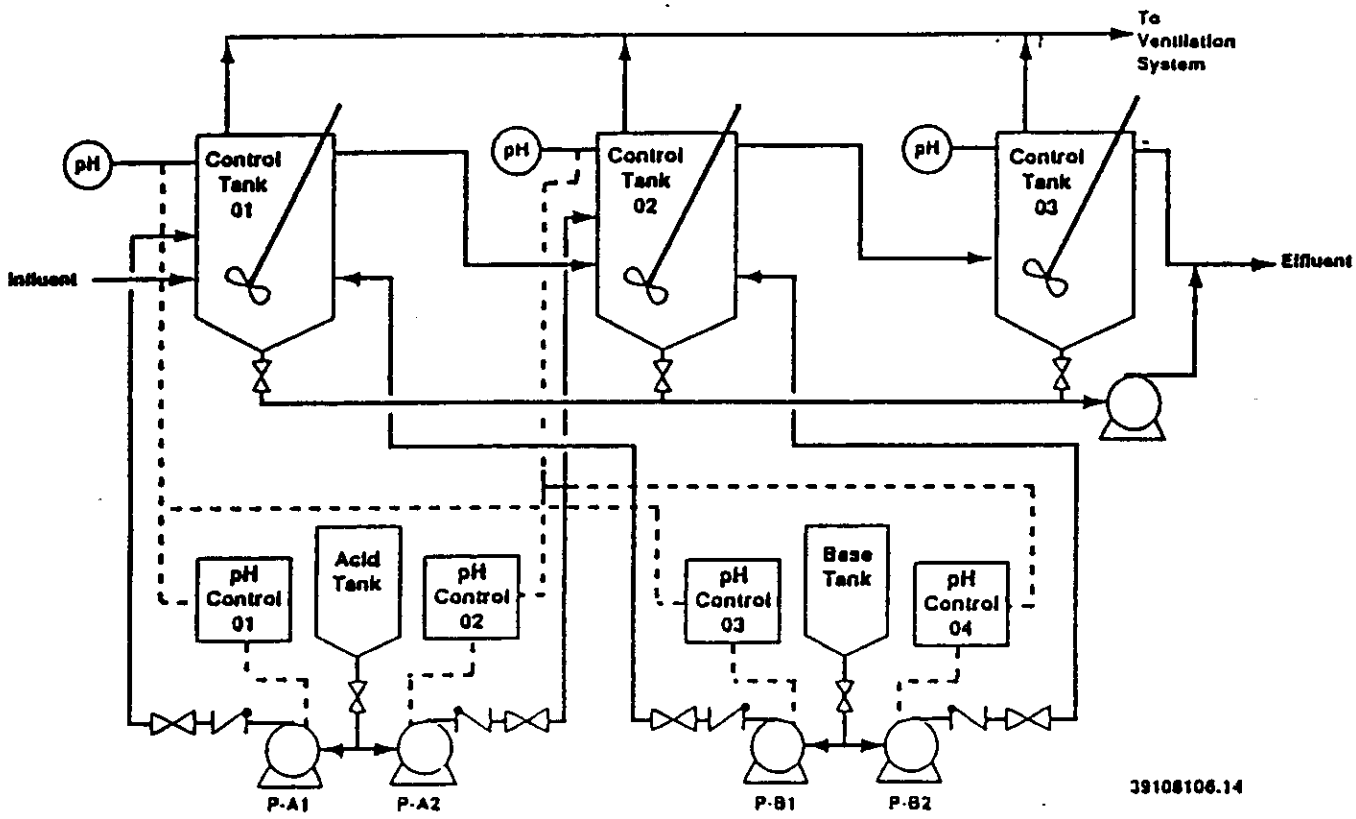
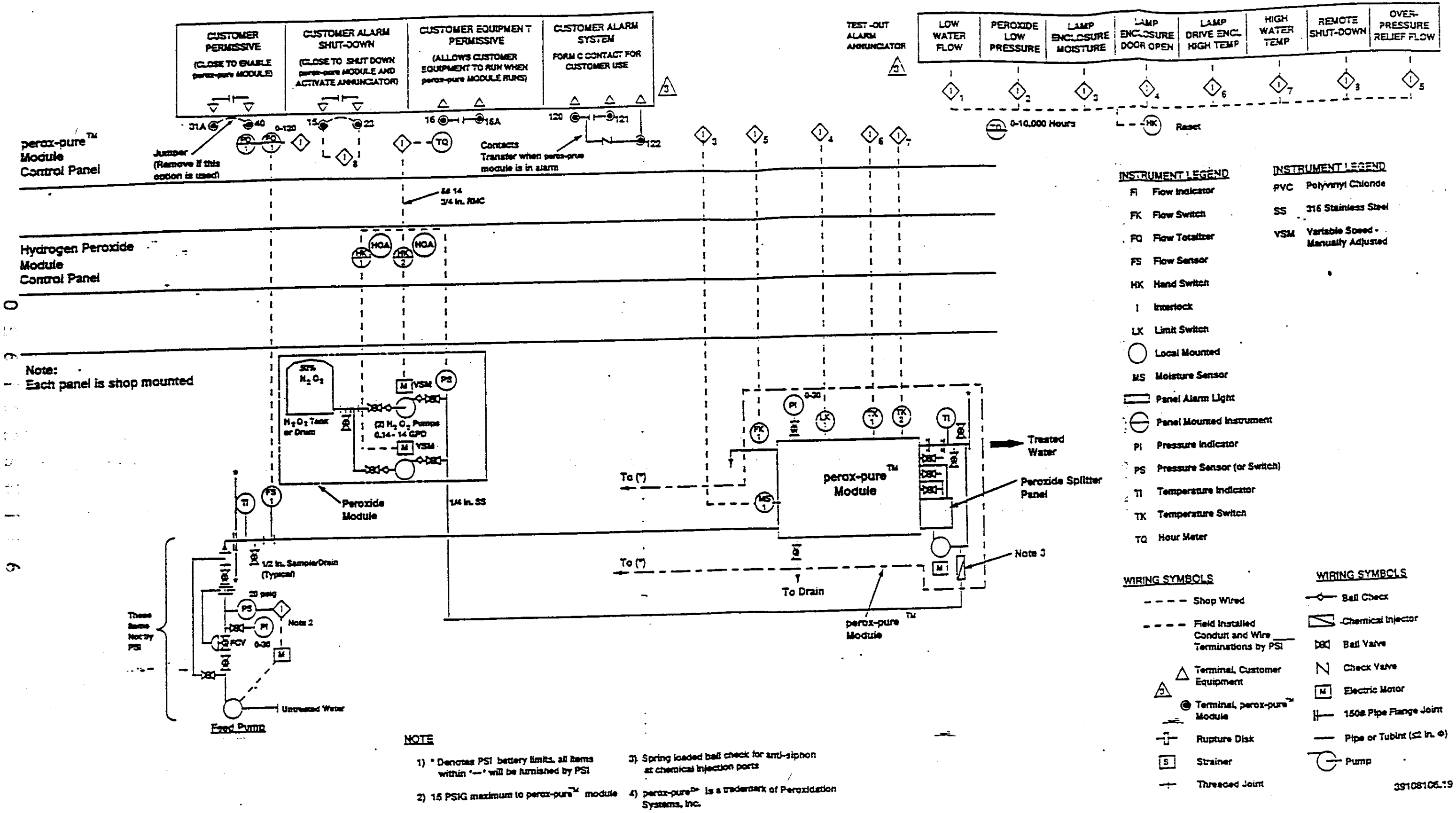


Figure 1-2: pH Flow Diagram



Note:
Each panel is shop mounted

NOTE

1) * Denotes PSI battery limits, all items within '—' will be furnished by PSI

2) 15 PSIG maximum to perox-pure™ module

3) Spring loaded ball check for anti-siphon at chemical injection ports

4) perox-pure™ is a trademark of Peroxidation Systems, Inc.

INSTRUMENT LEGEND

FI	Flow Indicator
FK	Flow Switch
FQ	Flow Totalizer
FS	Flow Sensor
HK	Hand Switch
I	Interlock
LX	Limit Switch
	Local Mounted
MS	Moisture Sensor
	Panel Alarm Light
	Panel Mounted Instrument
PI	Pressure Indicator
PS	Pressure Sensor (or Switch)
TI	Temperature Indicator
TK	Temperature Switch
TQ	Hour Meter

INSTRUMENT LEGEND

PVC	Polyvinyl Chloride
SS	316 Stainless Steel
VSM	Variable Speed - Manually Adjusted

WIRING SYMBOLS

- Shop Wired
- Field Installed Conduit and Wire Terminations by PSI
- Terminal, Customer Equipment
- Terminal, perox-pure™ Module
- Rupture Disk
- Strainer
- Threaded Joint

WIRING SYMBOLS

- Ball Check
- Chemical Injector
- Ball Valve
- Check Valve
- Electric Motor
- 150# Pipe Flange Joint
- Pipe or Tubing (≤2 in. Φ)
- Pump

39108106.19

Figure 1-3: Ultraviolet Oxidation Piping and Instrumentation Diagram

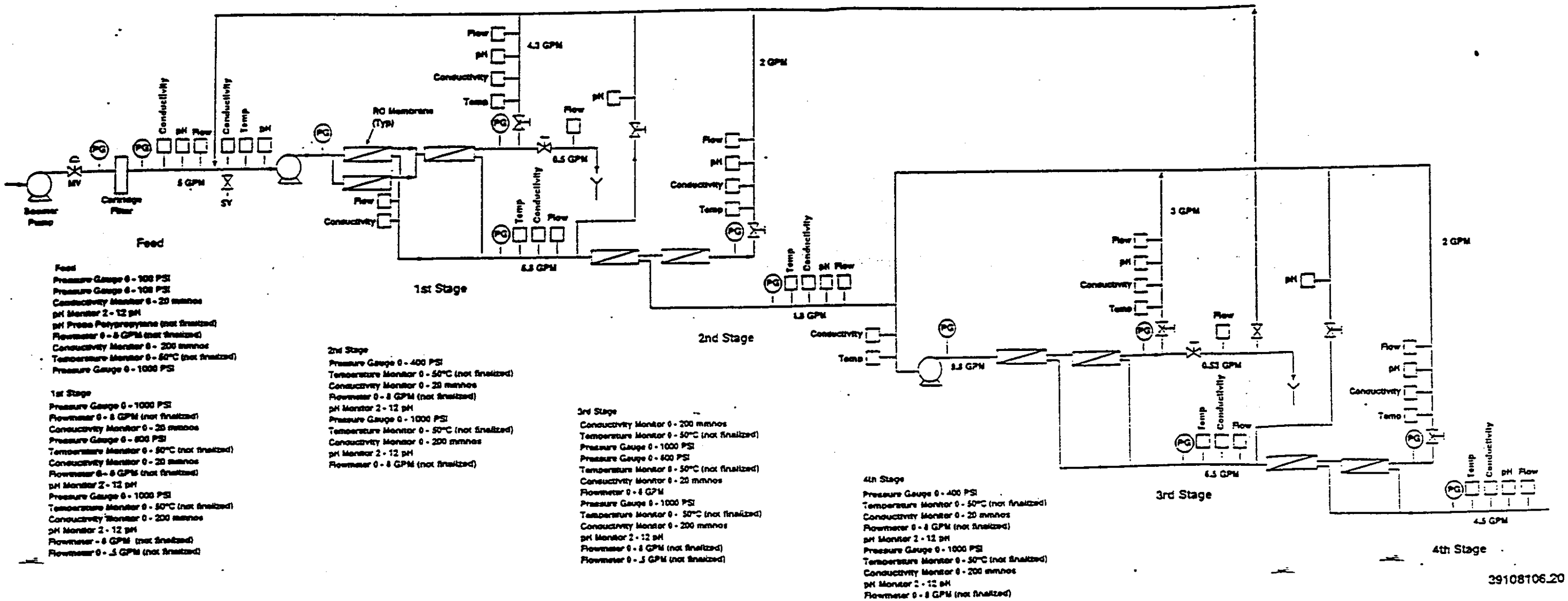


Figure 1-4: Reverse Osmosis Piping and Instrumentation Diagram

membrane, with an applied pressure of between 100 to 700 pounds per square inch.

The membrane pore size, composition, surface charge, and thickness, permit the water molecules to preferentially diffuse through the membrane while retaining the contaminant molecules (principally inorganics) in a concentrated waste solution. This concentrated waste solution, which does not pass through the membrane, is called the retentate or concentrate stream, and the portion that passes through the membrane is called the permeate stream. The retentate stream can be processed through several membranes in series to recover more of the waste water as permeate. Likewise, the permeate can be processed through several membranes to increase permeate purity.

The retentate from each stage is recycled back to a preceding stage. This recycle increases the velocity over the membranes and minimizes the retentate volume. The system is designed to provide flexibility on how much retentate is recycled and to where it is fed. A portion of the retentate from stages 1, 2, and 3 can be returned to the influent of stage 1. The retentate from stage 4 is returned to the influent of stage 3 along with a portion of stage 3 retentate. Retentate can be discharged from stages 1 and 3 and treated as secondary waste. This concentrated secondary waste will be used for additional evaporation studies to further concentrate the secondary waste. The high velocity resulting from recycling the retentate will help to minimize fouling by sweeping away precipitate or biological material off the membrane surface. This increases the membrane surface area available for pure water to pass through.

The reverse osmosis unit contains approximately 50 gallons (189 liters). No gases will be generated during reverse osmosis operation.

1.3.2 Ion Exchange and Granular Activated Carbon

Ion exchange and granular activated carbon will be considered together because the required test equipment and the critical parameters are very similar. The ion exchange and granular activated carbon processes act to concentrate the contaminants on the ion exchange or granular activated carbon media. The ion exchange resin and granular activated carbon can be used for polishing of the waste water. The granular activated carbon also can be used as an initial organic removal step.

The ion exchange process involves removing dissolved solids, including radionuclides, as ionic species from the waste water and binding the ions to a ion exchange media. The resin is usually in the form of small beads. The ion exchange resin is placed in a large vessel and the assemblies are called ion exchange beds. There could be several ion exchange beds placed in parallel or in series depending on the application. A flow distribution system within the ion exchange bed produces uniform waste water flow through the adsorption media. Uniform flow through an ion exchange bed is important to uniformly deplete the ion exchange resin to provide efficient use of the ion exchange resin capacity. The ion exchange bed can be regenerated to return the ion exchange resin to a state where the ion exchange again will remove

contaminants. Regeneration of ion exchange resin is performed by using either an acid or base, depending on the resin, and passing the acid or base through the ion exchange resin bed. The concentrated contaminants are removed into the regeneration solution. This regeneration solution is handled as a secondary waste.

Granular activated carbon is used primarily to remove organic contaminants from water. The organic species are adsorbed physically and retained on the granular carbon particle. The method of handling and using the granular activated carbon is very similar to ion exchange resins, except granular activated carbon is regenerated in a different manner.

The ion exchange and granular activated carbon equipment is in the very early stages of conceptual design. The primary difference between the ion exchange and granular activated carbon equipment will be the possible use of a regeneration system for the ion exchange resin. No granular activated carbon regeneration testing is planned. Testing involving ion exchange and granular activated carbon will be performed as a side stream operation to reduce the equipment size and duration of testing. Figure 1-5 presents a schematic drawing for the ion exchange and granular activated carbon systems.

1.4 Suspended Solids Removal

The purpose of testing filtration is to identify a filter, or filters, that can successfully remove the suspended solids (grit, colloids, biological growth, radionuclides, etc.) from waste water. The removal of these solids is essential for the protection of the downstream treatment systems and for the removal of other contaminants (e.g., organics, inorganics). A successful filter will be identified as one that is capable of maintaining a design flow rate with a minimum generation of secondary waste and fouling. The filtration technology investigated will consist of cartridge, microfiltration, and ultrafiltration. These technologies are very similar with the only difference being the particle size removed.

The filtration operation can be enhanced through use of a pretreatment step. The pretreatment can include pH adjustment or coagulation and flocculation. The coagulation and flocculation steps can be used with pH adjustment. Coagulation and flocculation involves the addition of an iron, alumina, or magnesium compound that will form a precipitate at a pH usually greater than 8. This precipitate enhances removal of heavy metals. The precipitate can be removed by using a filter with a precoat, or a clarifier. The precipitate can be dewatered using a filter press.

1.5 Storage Tanks

The C-018H Pilot Plant will have two double-shell 3,000-gallon (11,000-liter) interim storage tanks that will be capable of storing the waste water between tests on different treatment technologies or as feed material. These two storage tanks will be placed outside the C-018H Pilot Plant and will be plumbed to provide 6,000 gallons (22,700 liters) of storage. The inner shell of these tanks will be of stainless steel construction with outer shells

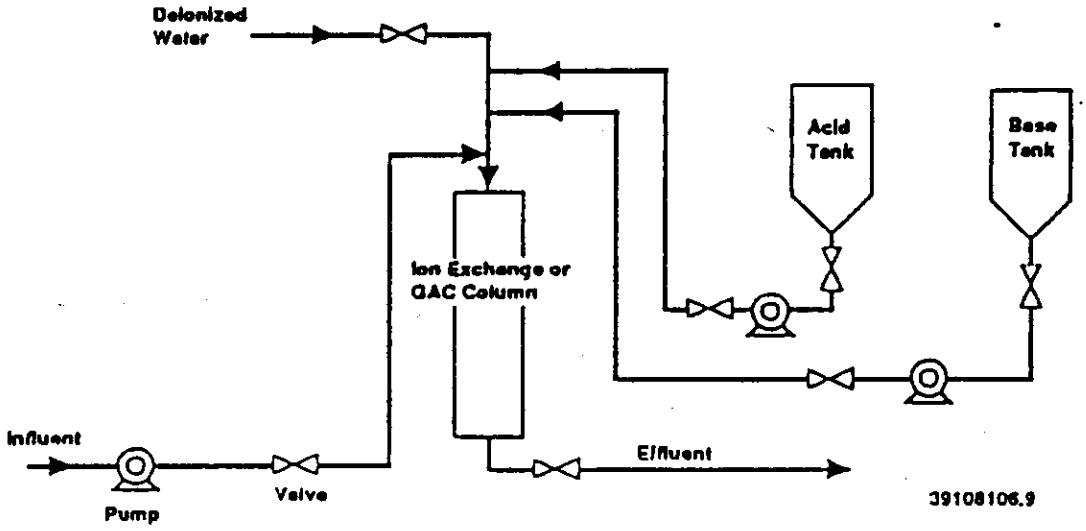


Figure 1-5: Schematic of the Ion Exchange and Granular Activated Carbon Systems

of carbon steel. Both tanks will be vented to the C-018H Pilot Plant ventilation system.

2.0 DESCRIBE THE SOURCE TERM. DESCRIBE THE PHYSICAL FORM OF EACH RADIONUCLIDE USED (OR CREATED) DURING THE PROCESS

The following characterization data (WHC 1990), Table 2-1, is specific to effluent from the LERF. The LERF will provide the radioactively contaminated effluent to be processed through the C-018H Pilot Plant and, hence, the source term.

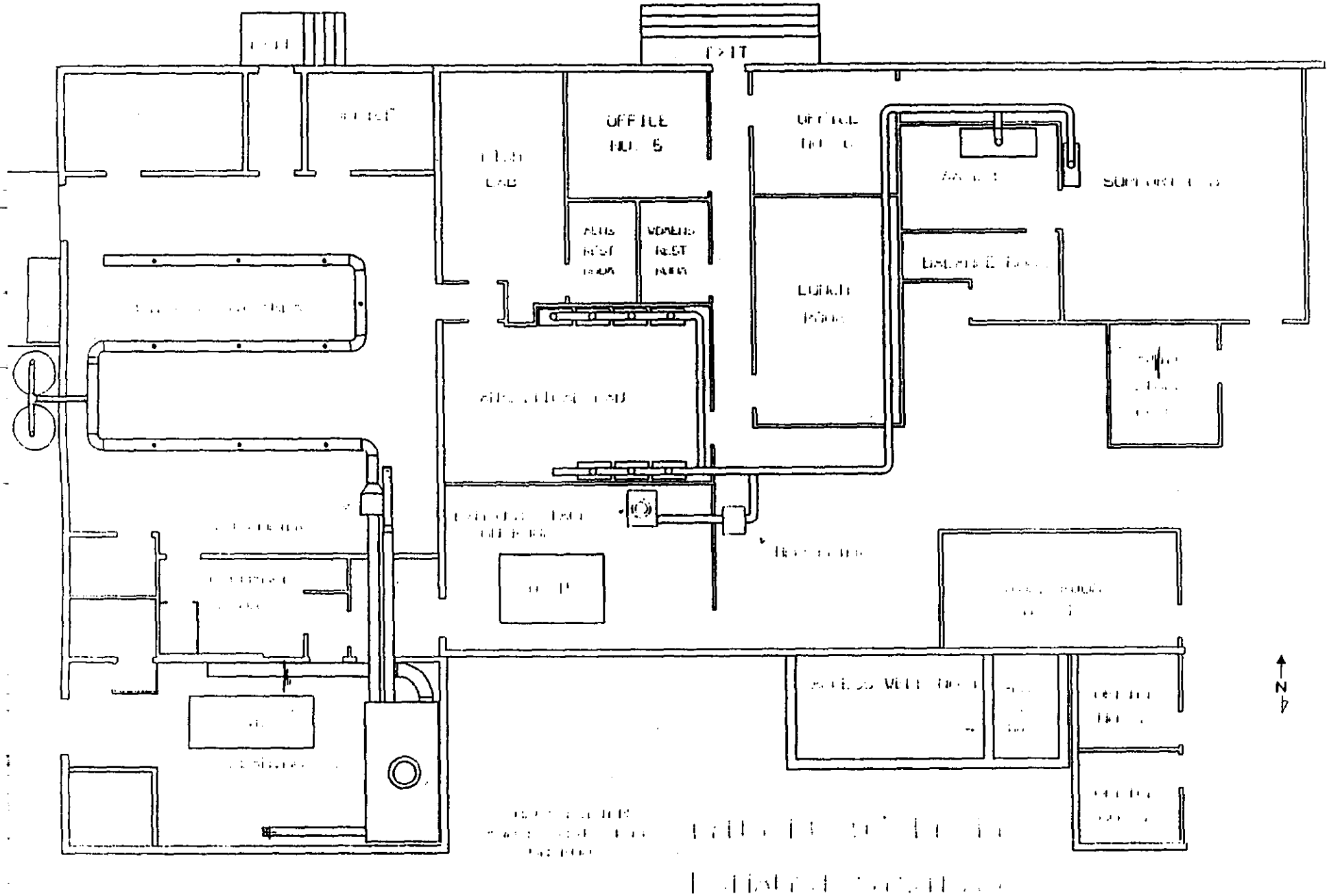
To obtain curies per year for each radionuclide, the proposed annual feed to the C-018H Pilot Plant of 500,000 gallons was converted to 1,892,720.6 liters and multiplied by the number of pico curies per liter. (The use of 500,000 gallons/year represents a plant specific maximum capacity and, thus, a very conservative estimate. The actual feed from the LERF is expected to be closer to 200,000 gallons/year.)

Table 2-1. C-018H Pilot Plant Annual Source Term (Annual Effluent Throughput)

Radionuclide	(pCi/L)	Ci/yr
Alpha	220,000	4.20 E-01
Beta	490,000	9.30 E-01
Sr-90	19,000	3.60 E-02
Ru-106	280,000	5.30 E-01
Ru-106 (oxide)	0.280	5.30 E-07
Ru-103	63,000	1.19 E-01
Ru-103 (oxide)	0.063	1.19 E-07
Cs-134	0.009	1.70 E-08
Cs-137	88,000	1.67 E-01
Pm-147	37,000	7.00 E-02
Uranium (gross)	160	3.02 E-04
H-3	68,000,000	1.29 E+02
Am-241	12,000	2.27 E-02
I-129 (elemental)	741	1.40 E-03
I-129 (methyl iodide)	39	7.38 E-05
Pu-238	2,200	4.16 E-03
Pu-241	190,000	3.60 E-01
Pu-239	19,000	3.60 E-02
Sn-113	34,000	6.43 E-02
Eu-155	1,400	2.65 E-03

3.0 PROVIDE DRAWINGS OF THE EMISSION UNIT FROM POINT OF ORIGIN OF THE SOURCE TO EMISSION TO THE ENVIRONMENT

There are two independent ventilation systems serving the 1706-KE building. Figure 3-1 is a simplified one line diagram showing which ventilation system serves which sections of the 1706-KE building. Figures 3-2 and 3-3 provide a more detailed view of the individual ventilation systems.



ANALYTICAL LABORATORY EXHAUST

PILOT PLANT EXHAUST

Figure 3-1: Simplified One Line Diagram of 1706-KE Ventilation System

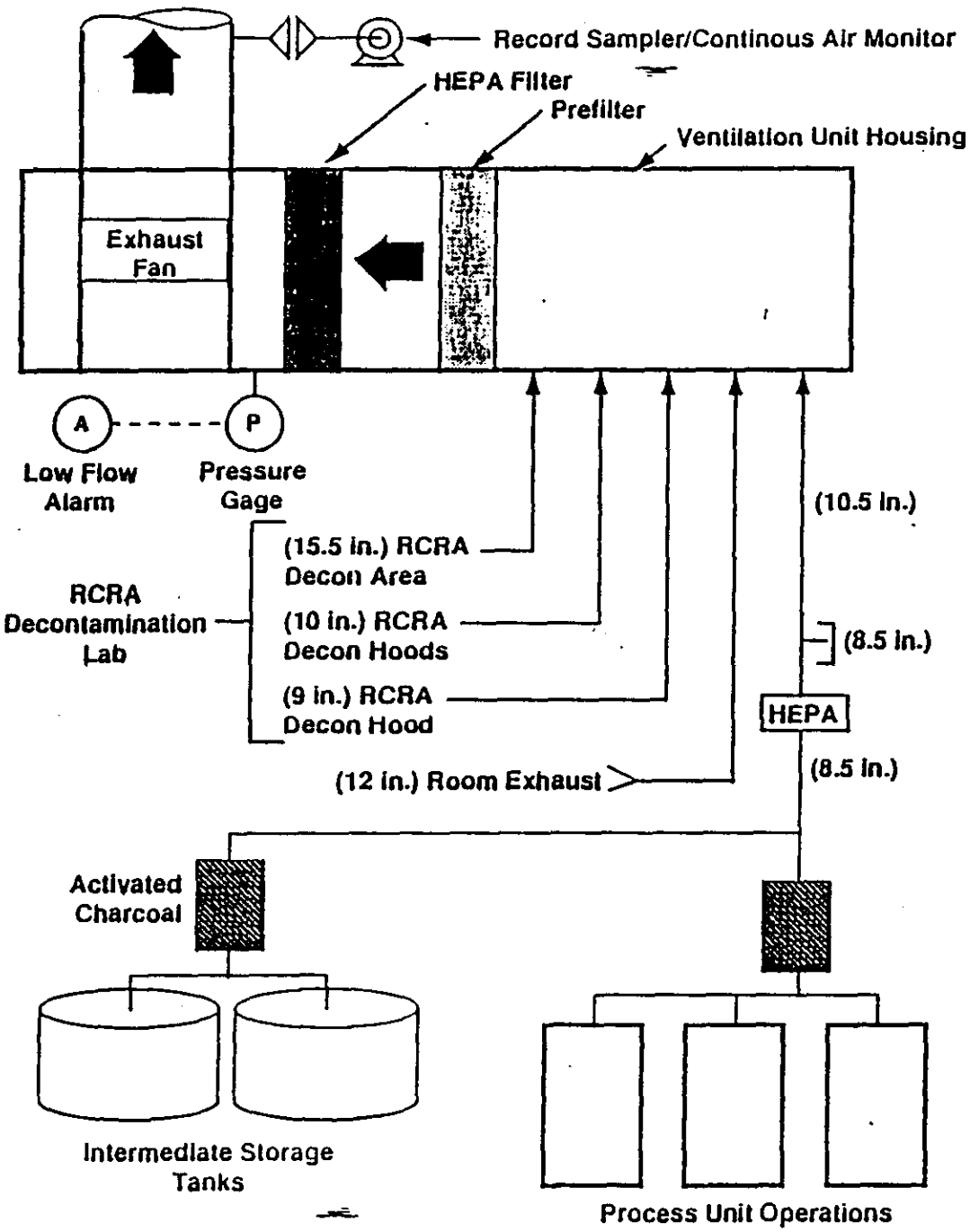


Figure 3-2: Process Area Ventilation System

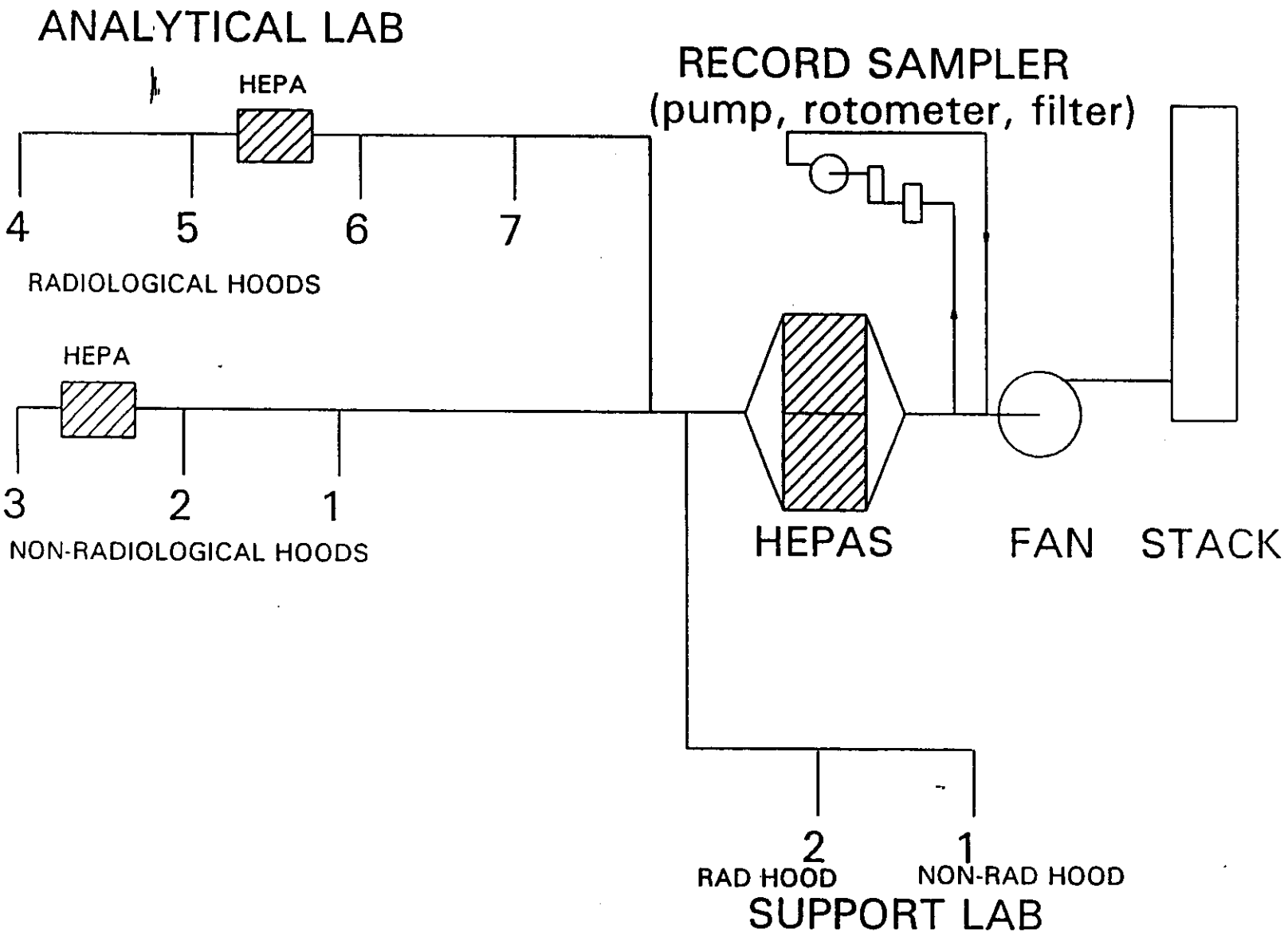


FIGURE 3-3: WASTEWATER PILOT PLANT LAB VENT SYSTEM

The process area, process equipment, tank trailers, and interim storage tanks (see Figure I-1) will be vented through the ventilation system depicted in Figure 3-2. This system has a rated capacity of 12,250 cfm. The ventilation system includes activated charcoal/first stage HEPA filters on individual branches of the ventilation system, followed by a coarse prefilter to remove large particulates and High Efficiency Particulate Air (HEPA) filters before discharge to atmosphere. (Note: This ventilation system also services a decontamination laboratory for Hanford Facility RCRA activities, where soil sampling equipment is cleaned. This decontamination laboratory is independent of the pilot plant operations.)

The analytical labs (see Figure I-1) will be vented through the ventilation system depicted in Figure 3-3. This system has a rated capacity of 12,000 cfm. The ventilation system includes HEPA filters on the radiological and non-radiological hoods, as shown, and final HEPA filtration before discharge to atmosphere. No modification work is planned for this ventilation system.

Release of volatile organics, volatile inorganics (e.g., mercury, ammonia, arsenic), and/or volatile radionuclides to the ventilation system is possible during transfers of the waste water. To minimize the release of these components and to maintain the integrity of the waste water composition to be studied, transfer points will be engineered to minimize volatilization of the waste water. To prevent any volatilization at the filling point, a fill tube extending to the bottom of the tanker will be used. Once the tanker arrives at the C-018H Pilot Plant, any receiving tank will be bottom-filled to control the release of volatile components. The first processing step planned at the C-018H Pilot Plant will, in most cases, adjust the waste water to a pH between 4 and 7. At this pH, most of the ammonia will be converted completely to ammonium ion and will no longer be vulnerable to release. Other potentially volatile inorganics will have a vapor pressure of less than 1 millimeter of mercury at the maximum operating temperatures of the waste water pilot plant. As a result, these potentially volatile inorganics are not considered to be vulnerable for release.

4.0 DESCRIBE THE RADIONUCLIDE CONTROL EQUIPMENT: THE EFFICIENCY OF EACH PIECE OF RADIONUCLIDE CONTROL EQUIPMENT FOR EACH RADIONUCLIDE THAT COULD CONTRIBUTE 10% OR MORE OF THE CEDE TO THE MEI

Carbon adsorption filters (for control of organics and elemental iodine) and HEPA filters (for control of particulate radionuclides) comprise the control devices used for removal of radioactivity from the C-018H Pilot Plant ventilation system.

In Section 7.0, it will be shown that tritium is the only radionuclide with the potential to contribute 10% or more of the CEDE to the MEI. It is understood that tritium is not controlled by HEPA filtration; therefore, no decontamination factor (DF) is claimed for the HEPAs in relationship to control of tritium. Similarly, no DF for control of tritium is claimed for the carbon adsorbers, though in reality carbon adsorption will provide an as

yet unknown level of tritium control. This control will be provided because an unknown quantity of the tritium is bound with the VOCs. Carbon adsorption controls approximately 99% of the VOCs (see discussion below). The following is, then, offered as a description of the radionuclide control equipment for the C-018H Pilot Plant.

A HEPA filter is a throwaway, extended-pleated medium, dry type filter. Hanford Site HEPA filters must meet the following requirements:

- Permissible penetration at test airflows shall be no greater than 0.03% when tested in accordance with NE F 3-43, Article 6.
- Filters shall have a minimum particle collection efficiency of 99.97% for 0.3 micron particle size thermally generated DOP aerosol (or equivalent) at 100% and at 20% of rated flow capacity for filters with a nominal airflow rating of 125 cfm (size 3) and larger and 100% rated flow for filters with a nominal rating below 125 cfm (NE F 3-43, Article 4).
- The pressure differential for air flow across a clean filter assembly when tested at appropriate nominal flows shall not exceed 1.3 inches water gauge (WG) for size 3 HEPAs and smaller, and 1.0 inch WG for HEPAs larger than size 3.

Loading of the HEPA filters will be minimized by roughing filters. The roughing filters are 24 inch by 24 inch by 1 - 7/8 inch thick glass fiber disposable filters of the same construction as household furnace filters.

Trapping of elemental radioiodine involves physical adsorption only, and the efficiency of nearly any good grade of activated carbon, impregnated or not, will be at least 99% (Burchsted et all). However, the primary function of the carbon adsorption units in the C-018H Pilot Plant will be control of organics.

A carbon adsorption unit is approximately 99% efficient for control of the pollutants for which it is designed until the adsorption capacity has been reached. In order to preclude the use of any adsorption unit that may have reached capacity, the units will be replaced when the total amount of volatile organic chemicals shipped to the pilot plant approaches 33 pounds (14.9 kilograms). The rationale behind this procedure is as follows.

Based on an average adsorption coefficient of 0.3 pound (136 grams) of volatile organic chemicals per pound of charcoal, each commercially available, 35-gallon (132.5-liter) charcoal drum will have a capacity of 33 pounds (15 kilograms) of volatile organic chemicals (Cheremisinoff and Ellersbosch 1978). The pilot plant will be designed to accommodate 5,000-gallon (19,000-liter) batches at a nominal flow rate of 5 gallons (18.9 liters) per minute. Using the waste characterization data from the "Stream-Specific Reports" (WHC, 1990) the range of volatile organic chemicals that can be expected in each 5,000 gallon (18,927 liter) batch is approximately 0.05 pounds per tanker to 4.0 pounds per tanker. At the nominal flow rate of

the pilot plant, this corresponds to a maximum of 0.24 pounds (108.9 grams) per hour of volatile organic chemicals.

Using the conservative assumption that 100 percent of the volatile organic chemicals will be volatilized in a single branch of the ventilation system (i.e., loading only one drum), the charcoal system will have sufficient capacity for 120 batches of the average site waste water or eight batches of the maximum waste water concentration.

Each of the 5,000-gallon batches will be analyzed for volatile organic chemicals. When the total amount of volatile organic chemicals shipped to the pilot plant approaches 33 pounds (14.9 kilograms), the charcoal filters will be replaced. This approach provides sufficient excess capacity because not all of the volatile organic chemicals will volatilize; this approach also is based on the capacity of only one of the two charcoal filters.

5.0 PROVIDE EXPECTED ANNUAL EMISSIONS WITH RADIONUCLIDE CONTROL EQUIPMENT IN PLACE, OR USING 40 CFR 61 APPENDIX D METHODOLOGY, FOR EACH RADIONUCLIDE THAT COULD CONTRIBUTE 10% OR MORE OF THE CEDE TO THE MEI

Expected annual emissions for all radionuclides emitted to atmosphere from the C-018H Pilot Plant were determined in two steps:

1) The ci/yr number (total annual throughput) for each radionuclide was taken from Table 2-1.

2) The extremely conservative approach of using the "front end" of the methodology set forth in Appendix D of 40 CFR 61, Subpart H was then applied to each of the curie numbers. ("Front end" means that no decontamination factor (DF) was claimed for HEPA filtration or filtration by the carbon adsorbers. The only DF claimed was E-03, for radionuclides in a liquid or particulate solid state. No DF was claimed for radionuclides in a gaseous state. It was assumed that the H-3 and I-129 [Methyl Iodide] would be in a gaseous state.)

Table 5-1, Expected Annual Emissions from C-018H Pilot Plant

Nuclide	Front End App. D Release (Ci/Yr)
Sr-90	3.60 E-05
Ru-106	5.30 E-04
Ru-106 (oxide)	5.30 E-10
Ru-103	1.19 E-04
Ru-103 (oxide)	1.19 E-10
Cs-134	1.70 E-11
Cs-137	1.67 E-04
Pm-147	7.00 E-05
Uranium (gross)	3.02 E-07
H-3	1.29 E+02
Am-241	2.27 E-05
I-129 (elemental)	1.40 E-06
I-129 (methyl I)	7.38 E-05
Pu-238	4.16 E-06
Pu-241	3.60 E-04
Pu-239	3.60 E-05
Sn-113	6.43 E-05
Eu-155	2.65 E-06

The only radionuclide with the potential to contribute greater than 10% of CEDE to the MEI is tritium (See Section 7.0). The projected tritium emissions constitute approximately 80% of the CEDE to the MEI.

6.0 DESCRIBE THE MONITORING EQUIPMENT. DESCRIBE THE MINIMUM DETECTABLE CONCENTRATION FOR EACH RADIONUCLIDE THAT COULD CONTRIBUTE 10% OR MORE OF THE CEDE TO THE MEI

As shown in Section 7.0, tritium is the only radionuclide that could contribute 10% or more of the CEDE to the MEI from the C-018H Pilot Plant. Also as shown in Section 7.0, the total projected dose from tritium emitted by the C-018H Pilot Plant will be approximately 0.004 mrem/yr. Because this dose is far below the defined "insignificant" level, there are no plans to incur the expense required to install a tritium monitoring system in the C-018H Pilot Plant. The following discussion describes the monitoring equipment that will be used in the pilot plant. This type of monitoring system is standard on the Hanford Site for facilities not having the capacity to provide 0.1 mrem/yr CEDE to the MEI, as defined in 40 CFR 61.

Stack effluent radionuclide content for both stacks at the C-018H Pilot Plant will be monitored with a particulate record sampler. The sample points in both stacks are located at the centerline of the duct. A 1/2 inch nozzle will withdraw a sample at a nominal flow rate of 1 cfm. The sampling train consists of a Gelman 47mm record sampler filter, a Dwyer rotameter, and a Gast air pump. The record sampler filter will be collected monthly and analyzed for total alpha and beta/gamma activity.

7.0 PROVIDE A PROJECTED DOSE TO THE MEI USING AN APPROVED CODE OR METHOD

The projected offsite dose to the MEI provided by the C-018H Pilot Plant was determined by applying dose factors derived from the EPA approved code, CAP 88 (Rhoads, 1991) as set forth in Table 7-1, to the expected annual emissions for each radionuclide, as set forth in Table 5-1.

(Note: It was assumed the 100-K location should have the same wind data and receptor locations as 100-N due to the shape of the Columbia River and Hanford Site boundary.)

(Note: Attached as Appendices A and B are the input and output files, respectively, for the GENII dose modeling that was performed for the convenience of DOH personnel. The results of the GENII modeling confirm the CAP 88 modeling results.)

Table 7-1, Offsite Dose to MEI from C-018H Pilot Plant
MEI Location is 9.9 km West

Nuclide	Front End App. D Release (Ci/Yr)	CAP 88 Dose Factor	Dose to MEI (mrem/yr)
Sr-90	3.60 E-05	6.45 E-02	2.32 E-06
Ru-106	5.30 E-04	3.08 E-02	1.63 E-05
Ru-106 (oxide)	5.30 E-10	3.08 E-02	1.63 E-11
Ru-103	1.19 E-04	2.10 E-03	2.50 E-07
Ru-103 (oxide)	1.19 E-10	2.10 E-03	2.50 E-13
Cs-134	1.70 E-11	4.62 E-02	7.85 E-13
Cs-137	1.67 E-04	3.53 E-02	5.90 E-06
Pm-147	7.00 E-05	1.68 E-03	1.18 E-07
Uranium (gross)	3.02 E-07	4.20 E+00	1.27 E-06
H-3	1.29 E+02	3.36 E-05	4.33 E-03
Am-241	2.27 E-05	1.94 E+01	4.40 E-04
I-129 (elemental)	1.40 E-06	3.19 E-01	4.47 E-07
I-129 (methyl I)	7.38 E-05	3.19 E-01	2.35 E-05
Pu-238	4.16 E-06	1.18 E+01	4.91 E-05
Pu-241	3.60 E-04	2.03 E-01	7.31 E-05
Pu-239	3.60 E-05	1.28 E+01	4.61 E-04
Sn-113	6.43 E-05	1.74 E-03	1.12 E-07
Eu-155	2.65 E-06	2.73 E-03	7.23 E-09
Total			5.39 E-03

As shown, the dose to the MEI of 5.37 E-03 mrem/yr constitutes only 5% of the 0.1 mrem/yr quantity defined as an "insignificant source".

REFERENCES

Burchsted et al. 1976, "Nuclear Air Cleaning Handbook - Design, Construction, and Testing of High-Efficiency Air Cleaning Systems for Nuclear Application", C. A. Burchsted, J. E. Kahn, and A. B. Fuller, ERDA-76-21, Oak Ridge National laboratory, Oak Ridge, Tennessee.

Cheremisinoff, P. N. and F. Ellersbosch, 1978, "Carbon Adsorption handbook", Ann Arbor Science Publishers Inc., Ann Arbor, Michigan.

NE F 3-43, "Nuclear Standard's Quality Assurance Testing of HEPA Filter", Office of Scientific and Technical Information, Oak Ridge, Tennessee, October, 1988.

Rhoads, K., September 1991, "Transmittal of Quality Assurance Documents for Facility Effluent Monitoring Plan Dose Calculations", Pacific Northwest Laboratories.

WHC, 1990, "Hanford Site Stream-Specific Reports", WHC-EP-0342, Westinghouse Hanford Company, Richland, Washington.

WHC, June 1991, "Functional Design Criteria for the 242-A Evaporator and PUREX Plant Condensate Treatment Facility", WHC-SD-C018-FDC-001 REV 2, Westinghouse Hanford Company, Richland, Washington.

APPENDIX A

GENII INPUT FILE

```
######################## Program GENII Input File ############  8 Jul 88 ####
Title: Emissions from C-018H Pilot Plant Treatment Facility
       \GENII\NOC.IN                                Created on 12-18-1991 at 07:30
OPTIONS======================== Default ==================================
F    Near-field scenario?      (Far-field)    NEAR-FIELD: narrowly-focused
F    Population dose?        (Individual)                 release, single site
F    Acute release?           (Chronic)     FAR-FIELD:  wide-scale release,
     Maximum Individual data set used                     multiple sites
                                  Complete                                Complete
TRANSPORT OPTIONS=========== Section   EXPOSURE PATHWAY OPTIONS===== Section
T  Air Transport                   1    T  Finite plume, external        5
F  Surface Water Transport         2    F  Infinite plume, external      5
F  Biotic Transport (near-field)  3,4   T  Ground, external               5
F  Waste Form Degradation (near)  3,4   F  Recreation, external          5
                                        T  Inhalation uptake             5,6
REPORT OPTIONS======================    F  Drinking water ingestion      7,8
T  Report AEDE only                     F  Aquatic foods ingestion       7,8
F  Report by radionuclide               T  Terrestrial foods ingestion   7,9
T  Report by exposure pathway           T  Animal product ingestion      7,10
F  Debug report on screen               T  Inadvertent soil ingestion

INVENTORY ##############################################################

 4   Inventory input activity units: (1-pCi  2-uCi  3-mCi  4-Ci  5-Bq)
 0   Surface soil source units (1- m2  2- m3  3- kg)
     Equilibrium question goes here
```

Use when	Release Terms: transport selected			Basic Concentrations: near-field scenario, optionally				
Release Radionuclide	Air /yr	Surface Water /yr	Buried Waste /m3	Air /m3	Surface Soil /unit	Deep Soil /m3	Ground Water /L	Surface Water /L
H 3	1.3E+02							
SR90	3.6E-05							
Y 90	3.6E-05							
RU103	1.2E-04							
RH103M	1.2E-04							
RU106	5.3E-04							
SN113	6.4E-05							
IN113M	6.4E-05							
I 129	7.5E-05							
CS134	1.7E-11							
CS137	1.7E-04							
PM147	7.0E-05							
EU155	2.7E-06							
U 238	3.0E-07							
TH234	3.0E-07							
PA234	4.8E-10							
PU238	4.2E-06							
PU239	3.6E-05							
PU241	3.6E-04							
AM241	2.3E-05							

```
--------|----Derived Concentrations-----|
Use when|   measured values are known   |
--------|-------------------------------|
Release |Terres. Animal  Drink   Aquatic|
Radio-  |Plant   Product Water   Food   |
nuclide |/kg     /kg     /L      /kg    |
--------|------- ------- ------- -------|

TIME ##############################################################################

1     Intake ends after (yr)
50    Dose calc. ends after (yr)
1     Release ends after (yr)
0     No. of years of air deposition prior to the intake period,
0     No. of years of irrigation water deposition prior to the intake period

FAR-FIELD SCENARIOS (IF POPULATION DOSE) ###########################################

0          Definition option: 1-Use population grid in file POP.IN
0                             2-Use total entered on this line

NEAR-FIELD SCENARIOS ###############################################################

           Prior to the beginning of the intake period: (yr)
0            When was the inventory disposed?  (Package degradation starts)
0            When was LOIC?  (Biotic transport starts)
0          Fraction of roots in upper soil (top 15 cm)
0          Fraction of roots in deep soil
0          Manual redistribution: deep soil/surface soil dilution factor
0          Source area for external dose modification factor (m2)
TRANSPORT ##########################################################################
           ====AIR TRANSPORT=================================SECTION 1=====
                  0-Calculate PM                |0       Release type (0-3)
 3         Option: 1-Use chi/Q or PM value      |F       Stack release (T/F)
                  2-Select MI dist & dir        |0       Stack height (m)
                  3-Specify MI dist & dir       |0       Stack flow (m3/sec)
0          Chi/Q or PM value                     |0       Stack radius (m)
5          MI sector index (1=S)                 |0       Effluent temp. (C)
9900.0     MI distance from release point (m)    |0       Building x-section (m2)
T          Use jf data, (T/F) else chi/Q grid    |0       Building height (m)

           ====SURFACE WATER TRANSPORT=======================SECTION 2=====
0          Mixing ratio model: 0-use value, 1-river, 2-lake
0          Mixing ratio, dimensionless
0          Average river flow rate for: MIXFLG=0 (m3/s), MIXFLG=1,2 (m/s),
0          Transit time to irrigation withdrawl location (hr)
           If mixing ratio model > 0:
0            Rate of effluent discharge to receiving water body (m3/s)
0            Longshore distance from release point to usage location (m)
0            Offshore distance to the water intake (m)
0            Average water depth in surface water body (m)
0            Average river width (m), MIXFLG=1 only
0            Depth of effluent discharge point to surface water (m), lake only
```

```
            ====WASTE FORM AVAILABILITY=========================SECTION 3=====
0           Waste form/package half life, (yr)
0           Waste thickness, (m)
0           Depth of soil overburden, m

            ====BIOTIC TRANSPORT OF BURIED SOURCE===============SECTION 4=====
T           Consider during inventory decay/buildup period (T/F)?
T           Consider during intake period (T/F)?    | 1-Arid non agricultural
0           Pre-Intake site condition.....          | 2-Humid non agricultural
                                                    | 3-Agricultural

EXPOSURE ##########################################################################

            ====EXTERNAL EXPOSURE================================SECTION 5=====
            Exposure time:                  |   Residential irrigation:
8766.0        Plume (hr)                    | T       Consider: (T/F)
4380.0        Soil contamination (hr)       | 0       Source: 1-ground water
0             Swimming (hr)                 |                 2-surface water
0             Boating (hr)                  | 0       Application rate (in/yr)
0             Shoreline activities (hr)     | 0       Duration (mo/yr)
0           Shoreline type: (1-river, 2-lake, 3-ocean, 4-tidal basin)
0           Transit time for release to reach aquatic recreation (hr)
0           Average fraction of time submersed in acute cloud (hr/person hr)

            ====INHALATION=======================================SECTION 6=====
8766.0      Hours of exposure to contamination per year
1           0-No resus-  1-Use Mass Loading          2-Use Anspaugh model
0.0001        pension      Mass loading factor (g/m3)   Top soil available (cm)

            ====INGESTION POPULATION=============================SECTION 7=====
 1          Atmospheric production definition (select option):
0             0-Use food-weighted chi/Q, (food-sec/m3), enter value on this line
              1-Use population-weighted chi/Q
              2-Use uniform production
              3-Use chi/Q and production grids (PRODUCTION will be overridden)
0           Population ingesting aquatic foods, 0 defaults to total (person)
0           Population ingesting drinking water, 0 defaults to total (person)
F           Consider dose from food exported out of region (default=F)

            Note below: S* or Source: 0-none, 1-ground water, 2-surface water
                                      3-Derived concentration entered above
            ==== AQUATIC FOODS / DRINKING WATER INGESTION=========SECTION 8====

F           Salt water? (default is fresh)

            USE          TRAN-   PROD-     -CONSUMPTION-  |
            ?    FOOD    SIT     UCTION    HOLDUP   RATE  |
            T/F  TYPE    hr      kg/yr     da       kg/yr |     DRINKING WATER
            ---  ------  -----   -------   ------   -----  |-------------------------
            F    FISH     0.00   0.0E+00     0.00     0.0  | 0     Source (see above)
            F    MOLLUS   0.00   0.0E+00     0.00     0.0  | T     Treatment? T/F
            F    CRUSTA   0.00   0.0E+00     0.00     0.0  | 0     Holdup/transit(da)
            F    PLANTS   0.00   0.0E+00     0.00     0.0  | 0     Consumption (L/yr)
```

====TERRESTRIAL FOOD INGESTION=====================SECTION 9=====

USE ? T/F	FOOD TYPE	GROW TIME da	--IRRIGATION-- S *	RATE in/yr	TIME mo/yr	YIELD kg/m2	PROD-UCTION kg/yr	--CONSUMPTION-- HOLDUP da	RATE kg/yr
T	LEAF V	90.00	0	0.0	0.0	1.5	0.0E+00	1.0	30.0
T	ROOT V	90.00	0	0.0	0.0	4.0	0.0E+00	5.0	220.0
T	FRUIT	90.00	0	0.0	0.0	2.0	0.0E+00	5.0	330.0
T	GRAIN	90.00	0	0.0	0.0	0.8	0.0E+00	180.0	80.0

====ANIMAL PRODUCTION CONSUMPTION==================SECTION 10====

USE ? T/F	FOOD TYPE	---HUMAN---- CONSUMPTION RATE kg/yr	HOLDUP da	TOTAL PROD-UCTION kg/yr	DRINK WATER CONTAM FRACT.	DIET FRAC-TION	GROW TIME da	-IRRIGATION-- S *	RATE in/yr	TIME mo/yr	YIELD kg/m3	STOR-AGE da
						----------STORED FEED----------						
T	BEEF	80.0	15.0	0.00	0.00	0.25	90.0	0	0.0	0.00	0.80	180.0
T	POULTR	18.0	1.0	0.00	0.00	1.00	90.0	0	0.0	0.00	0.80	180.0
T	MILK	270.0	1.0	0.00	0.00	0.25	45.0	0	0.0	0.00	2.00	100.0
T	EGG	30.0	1.0	0.00	0.00	1.00	90.0	0	0.0	0.00	0.80	180.0
						----------FRESH FORAGE----------						
	BEEF					0.75	45.0	0	0.0	0.00	2.00	100.0
	MILK					0.75	30.0	0	0.0	0.00	1.50	0.0

##

APPENDIX B

GENII OUTPUT FILE

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Emissions from C-018H Pilot Plant Treatment Facility

Executed on: 12/18/91 at 14:42:36

This is a far-field (wide-scale release, multiple site) scenario.
Release is chronic
Individual dose

THE FOLLOWING TRANSPORT MODES ARE CONSIDERED
Air

THE FOLLOWING EXPOSURE PATHS ARE CONSIDERED:
Finite plume, external
Ground, external
Inhalation uptake
Terrestrial foods ingestion
Animal product ingestion
Inadvertent soil ingestion

THE FOLLOWING TIMES ARE USED:

Intake ends after (yr):	1.0
Dose calculations ends after (yr):	50.0
Release ends after (yr):	1.0

========== FILENAMES AND TITLES OF FILES/LIBRARIES USED ==========

Input file name: \GENII\NOC.IN	12-18-91
GENII Default Parameter Values (28-Mar-90 RAP)	3-28-90
Radionuclide Master Library (11/15/90 PDR)	11-15-90
Food Transfer Factor Library - (RAP 29-Aug-88) (UPDATED LEACHING FA	8-29-88
External Dose Factors for GENII in person Sv/yr per Bq/n (8-May-90 R	5-08-90
Internal Dose Increments, Worst Case Solubilities, 12/3/90 PDR	12-03-90
EXTGAM - Gamma Energies by Group for Finite Plume (13-May-90 RAP)	5-14-90
100 AREA - 10 M - Pasquill A - F (1983 - 1987 Average)	

==========

Release Radionuclide	Air Ci/yr	Surface Water Ci/yr	Buried Source Ci/m3
	----Release Terms----		
H 3	1.3E+02	0.0E+00	0.0E+00
SR90	3.6E-05	0.0E+00	0.0E+00
Y 90	3.6E-05	0.0E+00	0.0E+00
RU103	1.2E-04	0.0E+00	0.0E+00
RH103M	1.2E-04	0.0E+00	0.0E+00
RU106	5.3E-04	0.0E+00	0.0E+00
SN113	6.4E-05	0.0E+00	0.0E+00
IN113M	6.4E-05	0.0E+00	0.0E+00
I 129	7.5E-05	0.0E+00	0.0E+00
CS134	1.7E-11	0.0E+00	0.0E+00
CS137	1.7E-04	0.0E+00	0.0E+00
PM147	7.0E-05	0.0E+00	0.0E+00
EU155	2.7E-06	0.0E+00	0.0E+00
U 238	3.0E-07	0.0E+00	0.0E+00
TH234	3.0E-07	0.0E+00	0.0E+00
PA234	4.8E-10	0.0E+00	0.0E+00
PU238	4.2E-06	0.0E+00	0.0E+00
PU239	3.6E-05	0.0E+00	0.0E+00
PU241	3.6E-04	0.0E+00	0.0E+00
AM241	2.3E-05	0.0E+00	0.0E+00

========== AIR TRANSPORT ==========

Joint frequency data input.

9.9E+03 Maximum individual distance from release point (m)

5.0E+00 Maximum individual sector index (Wind Toward W)

Ground level release.

========== EXTERNAL EXPOSURE ==========

8.8E+03 Hours of exposure to plume

4.4E+03 Hours of exposure to ground contamination

========== INHALATION ==========

8.8E+03 Hours of inhalation exposure per year

1 Resuspension model: 1-Mass Loading, 2-Anspaugh

1.0E-04 Mass loading factor (g/m3)

========== INGESTION POPULATION ==========

1 Atmospheric production definition: 1 - Use population-weighted chi/Q

========== TERRESTRIAL FOOD INGESTION ==========

FOOD TYPE	GROW TIME d	S *	--IRRIGATION-- RATE in/yr	TIME mo/yr	YIELD kg/m2	PROD-UCTION kg/yr	--CONSUMPTION-- HOLDUP d	RATE kg/yr
Leaf Veg	90.0	0	0.0	0.0	1.5		1.0	3.0E+01
Oth. Veg	90.0	0	0.0	0.0	4.0		5.0	2.2E+02
Fruit	90.0	0	0.0	0.0	2.0		5.0	3.3E+02
Cereals	90.0	0	0.0	0.0	0.8		180.0	8.0E+01

========== ANIMAL FOOD INGESTION ==========

FOOD TYPE	---HUMAN---- CONSUMPTION RATE kg/yr	HOLDUP d	TOTAL PROD-UCTION kg/yr	DRINK WATER CONTAM FRACT.	STORED FEED---- DIET FRAC-TION	GROW TIME d	-IRRIGATION-- S *	RATE in/yr	TIME mo/yr	YIELD kg/m3	STOR-AGE d
Meat	8.0E+01	15.0		0.00	0.3	90.00	0	0.0	0.0	0.80	180.0
Poultry	1.8E+01	1.0		0.00	1.0	90.00	0	0.0	0.0	0.80	180.0
Cow Milk	2.7E+02	1.0		0.00	0.3	45.00	0	0.0	0.0	2.00	100.0
Eggs	3.0E+01	1.0		0.00	1.0	90.00	0	0.0	0.0	0.80	180.0
					FRESH FORAGE----						
Meat					0.75	45.0	0	0.0	0.0	2.00	100.0
Cow Milk					0.75	30.0	0	0.0	0.0	1.50	0.0

==========

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Emissions from C-018H Pilot Plant Treatment Facility

Executed on: 12/18/91 at 14:43:01

1.4E-07 Individual chi/Q

GENII Dose Calculation Program
(Version 1.485 3-Dec-90)

Case title: Emissions from C-018H Pilot Plant Treatment Facility

Executed on: 12/18/91 at 14:44:27

Release period:	1.0
Uptake/exposure period:	1.0
Dose commitment period:	50.0
Dose units:	Rem

Organ	Committed Dose Equivalent	Weighting Factors	Weighted Dose Equivalent
Gonads	4.9E-06	2.5E-01	1.2E-06
Breast	4.6E-06	1.5E-01	7.0E-07
R Marrow	7.4E-06	1.2E-01	8.9E-07
Lung	4.9E-06	1.2E-01	5.9E-07
Thyroid	8.3E-06	3.0E-02	2.5E-07
Bone Sur	2.7E-05	3.0E-02	8.1E-07
LL Int.	4.7E-06	6.0E-02	2.8E-07
UL Int.	4.7E-06	6.0E-02	2.8E-07
S Int.	4.6E-06	6.0E-02	2.8E-07
Stomach	4.6E-06	6.0E-02	2.8E-07
Liver	3.7E-06	6.0E-02	2.2E-07
Internal Effective Dose Equivalent			5.8E-06
External Dose			3.3E-10
Annual Effective Dose Equivalent			5.8E-06

Controlling Organ:	Bone Sur
Controlling Pathway:	Ing
Controlling Radionuclide:	H 3
Total Inhalation EDE:	1.5E-06
Total Ingestion EDE:	4.3E-06

Release period: 1.0
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

		Dose Commitment Year 1	2	3	...		
Internal Intake Year:	3			0.0E+00	...		
	2		0.0E+00	+ 0.0E+00	...		Internal Effective Dose Equivalent
	1	4.7E-06 +	4.5E-08 +	3.3E-08 +	...	= 5.8E-06	
Internal Annual Dose		4.7E-06 +	4.5E-08 +	3.3E-08 +	...	= 5.8E-06	Cumulative Internal Dose
External Annual Dose		3.3E-10	0.0E+00	0.0E+00	...	3.3E-10	
Annual Dose		4.7E-06 +	4.5E-08 +	3.3E-08 +	...	= 5.8E-06	Cumulative Dose
						4.7E-06	Maximum Annual Dose Occurred In Year 1

Release period: 1.0
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Committed Dose Equivalent by Exposure Pathway

Pathway	Lung	Stomach	S Int.	UL Int.	LL Int.	Bone Su	R Marro	Testes
Inhale	6.7E-07	4.4E-07	4.4E-07	4.5E-07	4.5E-07	2.1E-05	2.1E-06	7.3E-07
Leaf Veg	1.2E-07	1.2E-07	1.2E-07	1.2E-07	1.3E-07	3.7E-07	1.7E-07	1.2E-07
Oth. Veg	8.8E-07	8.8E-07	8.8E-07	8.9E-07	8.9E-07	1.4E-06	1.1E-06	8.9E-07
Fruit	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.3E-06	1.9E-06	1.7E-06	1.3E-06
Cereals	2.1E-07	2.1E-07	2.1E-07	2.2E-07	2.2E-07	3.7E-07	2.7E-07	2.2E-07
Meat	3.3E-07	3.3E-07	3.3E-07	3.3E-07	3.3E-07	3.9E-07	4.1E-07	3.3E-07
Poultry	7.6E-08	7.6E-08	7.6E-08	7.6E-08	7.6E-08	8.9E-08	9.3E-08	7.6E-08
Cow Milk	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.1E-06	1.3E-06	1.4E-06	1.1E-06
Eggs	1.3E-07	1.3E-07	1.3E-07	1.3E-07	1.3E-07	1.5E-07	1.6E-07	1.3E-07
Soil Ing	9.3E-13	1.3E-12	1.7E-12	4.6E-12	1.2E-11	4.3E-10	3.6E-11	7.0E-12
Total	4.9E-06	4.6E-06	4.6E-06	4.7E-06	4.7E-06	2.7E-05	7.4E-06	4.9E-06

Pathway	Ovaries	Muscle	Thyroid	Kidneys	Liver	Spleen
Inhale	7.3E-07	4.4E-07	4.6E-07	2.7E-12	3.5E-06	2.5E-14
Leaf Veg	1.2E-07	1.2E-07	4.3E-07	2.4E-11	4.0E-08	5.1E-14
Oth. Veg	8.9E-07	8.8E-07	1.4E-06	3.3E-11	5.6E-08	7.1E-14
Fruit	1.3E-06	1.3E-06	1.8E-06	3.3E-11	5.6E-08	7.3E-14
Cereals	2.2E-07	2.1E-07	3.9E-07	1.2E-11	2.1E-08	8.9E-15
Meat	3.3E-07	3.3E-07	4.9E-07	1.2E-12	8.4E-11	6.5E-14
Poultry	7.6E-08	7.6E-08	7.6E-08	3.9E-13	9.3E-14	2.4E-19
Cow Milk	1.1E-06	1.1E-06	3.1E-06	7.4E-12	3.6E-12	2.7E-14
Eggs	1.3E-07	1.3E-07	1.5E-07	5.3E-13	7.8E-12	4.0E-19
Soil Ing	6.9E-12	9.0E-13	3.9E-10	4.2E-14	7.4E-11	4.4E-17
Total	4.9E-06	4.6E-06	8.3E-06	1.1E-10	3.7E-06	3.2E-13

Release period:	1.0	
Uptake/exposure period:	1.0	
Dose commitment period:	50.0	
Dose units:	Rem	

External Dose by Exposure Pathway

Pathway	
Plume	3.6E-12
Sur Soil	3.3E-10
Total	3.3E-10

Release period: 1.0
Uptake/exposure period: 1.0
Dose commitment period: 50.0
Dose units: Rem

Radio-nuclide	Inhalation Effective Dose Equivalent	Ingestion Effective Dose Equivalent	External Dose	Internal Effective Dose Equivalent	Annual Effective Dose Equivalent
H 3	4.3E-07	4.1E-06	0.0E+00	4.5E-06	4.5E-06
SR 90	2.6E-10	1.8E-09	6.3E-15	2.0E-09	2.0E-09
Y 90	1.1E-11	1.3E-10	3.5E-13	1.4E-10	1.4E-10
RU 103	3.9E-11	4.8E-11	1.7E-11	8.8E-11	1.0E-10
PD 103	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
RH 103M	2.2E-14	2.0E-13	6.4E-15	2.2E-13	2.2E-13
RU 106	8.9E-09	3.2E-09	1.5E-10	1.2E-08	1.2E-08
SN 113	2.5E-11	5.0E-11	2.3E-13	7.5E-11	7.5E-11
IN 113M	9.6E-14	1.8E-12	1.0E-11	1.9E-12	1.2E-11
I 129	4.1E-10	1.1E-07	1.5E-12	1.1E-07	1.1E-07
CS 134	2.6E-17	8.3E-16	3.9E-17	8.5E-16	8.9E-16
CS 137	1.9E-10	6.2E-09	1.5E-10	6.4E-09	6.6E-09
PM 147	1.0E-10	1.9E-11	8.4E-16	1.2E-10	1.2E-10
SM 147	2.1E-22	4.0E-21	0.0E+00	4.2E-21	4.2E-21
EU 155	4.0E-12	1.1E-12	1.1E-13	5.1E-12	5.2E-12
PU 238	5.9E-08	2.9E-09	2.3E-16	6.2E-08	6.2E-08
U 238	1.3E-09	1.8E-11	1.8E-17	1.3E-09	1.3E-09
TH 234	3.8E-13	1.0E-12	9.7E-15	1.4E-12	1.4E-12
PA 234	1.5E-17	2.7E-16	1.6E-15	2.9E-16	1.8E-15
PU 241	1.1E-07	5.2E-09	2.0E-20	1.1E-07	1.1E-07
AM 241	3.7E-07	1.8E-08	1.8E-13	3.9E-07	3.9E-07
PU 239	5.6E-07	2.8E-08	2.8E-15	5.9E-07	5.9E-07